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Quality Route Planning for Alternative Transport Modalities

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ABSTRACT

Bicyclists, pedestrians, and other non-motorized road-users have different concerns about the surrounding traffic and environmental factors, e.g., air quality, bicycle lane-widths, types, and speeds of adjacent traffic, etc., than regular (automobile) commuters. Such additional considerations are not usually accounted for in traditional vehicle routing by digital map or navigation applications. This disclosure describes techniques of route-planning that optimize safety and overall convenience for alternate transport modalities such as bicycle, open-top vehicles, non-motorized vehicles, etc. and for pedestrians. The techniques leverage location data, traffic data, street-level imagery, aerial imagery, etc., and assign a score to a travel route based on expected quality of travel experience. Implementation of the techniques in a digital map or navigation application can offer a superior navigation experience to a thus-far under-served cyclist, pedestrian, and non-motorized vehicle user base.

KEYWORDS

- Digital map
- Bicycle navigation
- Pedestrian navigation
- Non-motorized traffic
- Telemetry
- Geographic information systems (GIS)
- Global positioning system (GPS)
- Air quality
- Air pollution

BACKGROUND

Bicyclists, pedestrians, and, to a lesser extent, occupants of open-top vehicles care a lot more about the surrounding traffic and environmental factors, e.g., air quality, than regular (automobile) commuters. As for all road users, convenience and safety are important concerns, but for bicyclists, there are additional considerations that are not usually accounted for in traditional vehicle routing, e.g., using in-vehicle navigation systems or digital map applications.

A vast corpus of data exists relating to vehicular traffic, streets and street lanes, and environmental factors such as air quality. Various live-updated event streams useful for predicting safety hazards, delays, etc. are also available. Currently, routing for bicycles and other non-motorized vehicle traffic is done primarily based on the knowledge of dedicated bicycle lanes, trails, etc., and, like all other routing, optimizes for time and distance along this expanded travel network. Although apps catering to bicyclists and pedestrians exist, most such apps focus on the athletic performance of the bicyclist or pedestrian, using social media and gamification tools as necessary. Besides, such apps typically require that a user start and stop a trip manually within the app and then upload the GPS track to a server.

DESCRIPTION

This disclosure describes techniques of route-planning for bicyclists, pedestrians, and occupants of open-top vehicles to improve safety and overall convenience. A generalized quality-of-life metric and its optimization are described. Per the techniques, datasets that qualitatively and quantitatively characterize the expected surroundings along each candidate route are obtained and utilized for routing, with specific user permission for such use.

Data such as user location data, traffic data, street-level imagery, aerial imagery, inferred knowledge from machine learning models, etc., are leveraged to weigh each bikeable (or pedestrian) segment with an all-inclusive safety and convenience metric to offer a navigation experience that is superior to a thus-far somewhat under-served cyclist, pedestrian, and non-motorized user base, as well as users who travel in non-standard vehicles, e.g., open-top or convertible cars. This metric, also referred to as a score of quality of life or quality of travel experience, factors in many measurable health-related aspects, balancing distance and time against expected user well-being.

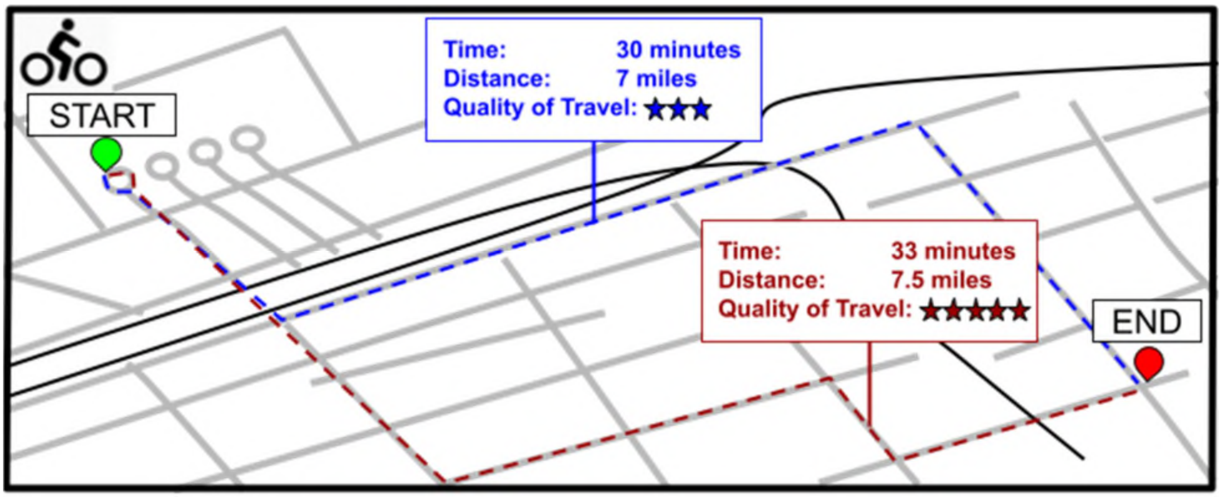

Fig. 1: Route planning that includes a quality-of-travel (or similar) metric

Fig. 1 illustrates an example of route planning that utilizes a quality-of-travel (or similar) metric. Upon receiving a specified start and an end point, a digital map/navigation/routing app reports a conventionally calculated route (shown in blue) that minimizes time and distance, and also, a perhaps slightly longer route (shown in brown) that has a better quality-of-travel metric.

The most important piece of knowledge is still the basic knowledge of the road network amenable to traffic by the chosen mode of transport. However, to identify routes for alternative transport modalities such as foot, bicycle, open-top vehicle, etc. each segment in the network is additionally assigned multiple scores, such as:

- a score based on the air quality of the area;
- a score based on the road length and width useable by the chosen mode of transport;
- a score based on the traffic quality (e.g., for cyclists, this score can be inversely related to the speed of the vehicles in the lane adjacent to the bicycle lanes, and also inversely

related to the number of large vehicles, such as buses and trucks, in the adjacent lane, etc.);

- a score based on the past history of traffic events (e.g., accidents) in that segment involving any vehicles and, weighted higher, the user's particular type of vehicle; etc.

The scores are described in further detail below.

<u>*Air quality score*</u>

The air quality score can be derived from the measurements of NO2 and other pollutants that are taken during regular street-level collections. These happen more frequently as the collection cadence is increased, including through the use of user-generated content. Additionally, pollution data is available at a larger scale (but at lower resolution) from satellite data. Each area on the map can then be assigned an air quality score, and the scores can be mapped directly to a quality of life score based on the frequency of a particular user's use of road segments in that area or the time spent on the route/segment traversal (both accessed with specific user permission); the known links of a particular pollutant to the area, the length of exposure to and the potential health effects of that pollutant; etc. These measurements can also be linked to the time-of-day of the collection, such that with sufficient recently-collected data, a model can be built that predicts hourly concentrations of pollutants along various segments of the suggested route.

In addition, near-real-time data on atmospheric conditions (e.g., rain, wind, snow, etc.) can also be maintained. One possible source of this information can be telemetry-equipped cars with automatic window wipers and/or traction control systems that provide such data with permission of the car owner/operator. With such telemetry readings, on-ground weather conditions can be modeled in (near) real time. Such weather data can help with planning longer trips and can be factored into the quality of travel experience score for each affected segment along a candidate route. Longer biking and open-top vehicle trips can particularly benefit from use of this data in computing the score.

Road quality score

The road/lane width score can be determined with the use of a machine-learning model run on aerial imagery that segments paved roads into lanes by detecting lane markings, vehicle patterns, etc. In general, a wider lane can be deemed safer for travel. Another important feature is whether a lane is a dedicated one or shared with other modes of transport, and, if so, which modes these are and by how much their average speed may differ from the vehicle for which the score is being calculated. Additionally, aerial imagery and/or LiDAR-based street data collection can help determine the existence of separation barriers between a bike lane and car lanes, with the presence of a barrier contributing positively to the quality of travel experience score. Aerial imagery can also be used to determine the safety and convenience of night-time travel, as satellite and other imagery can be used to gauge the amount of ambient light.

Traffic quality score

The traffic quality score can be derived from global positioning sensor (GPS) data as well as the street-level imagery. GPS data from various vehicles (obtained with permission) can be used to determine the average speed and the overall adherence of drivers to the posted traffic signs and general traffic rules, e.g., by doing a statistical analysis of speed, vehicular starts and stops, and by computing the variance. Street-level imagery can be mined, e.g., using machine-learning models and tools such as independent component analysis, for the presence of oversize vehicles, particularly in a lane adjacent to the bicycle lane. Past history of accidents and (suspected or actual) traffic violations can also be inferred from historical data.

Together, this data can be used to assign an overall safety score to each segment and make a prediction about the likelihood of having an accident or a risky maneuver on a particular segment. With knowledge of the frequency of travel from A to B, a candidate route passing through a given segment can be rated with a quality of life, a quality of travel experience, or more generally, a quality-of-life metric.

Additional factors can be rolled into this metric based on the availability and ease of collection of the appropriate data. Some examples of such data include known crime and assault statistics, scenic value of a route, fumes from larger emitters such as known industrial sites, refineries, feedlots, etc. and so on. In computing air pollution from large emitters, the wind direction can be taken into account when computing the experience score along each segment to determine whether the route segment is upwind or downwind from the fumes.

The individual component scores as described above can be combined into a linear combination. A particular route can be assigned a score based on the estimated quality of travel experience along the route while a frequently-traveled route can be assigned a quality-of-life metric. Candidate routes with difference in time and distance from the shortest route that is not greater than a certain threshold fraction can be considered and recommended if one or more of the component scores for the candidate routes are higher. The user can be put in control of the value ascribed to the various individual components of the score. The user preferences can be used to determine the weights in the linear combination used to weigh the component scores. The suggested route can be the one that maximizes this overall weighted combination metric.

Adjustments to this general approach can be made for non-bicycle, non-motorized transportation. For pedestrian/wheelchair traffic, the width of the sidewalk, its distance from the road, whether the sidewalk is elevated or not, and whether the sidewalk is multi-use (e.g., allows bicycle travel or is pedestrian-only) can be considered. For convertible cars, important aspects of the quality of travel experience (or quality of life) metric can be air quality, the presence of oversize vehicles, the presence of diesel-powered vehicles, etc.

Further to the descriptions above, a user may be provided with controls allowing the user to make an election as to both if and when systems, programs or features described herein may enable the collection of user information (e.g., information about a user’s travel modality, routes taken, a user’s preferences, or a user’s current location), and if the user is sent content or communications from a server. In addition, certain data may be treated in one or more ways before it is stored or used, so that personally identifiable information is removed. For example, a user’s identity may be treated so that no personally identifiable information can be determined for the user, or a user’s geographic location may be generalized where location information is obtained (such as to a city, ZIP code, or state level), so that a particular location of a user cannot be determined. Thus, the user may have control over what information is collected about the user, how that information is used, and what information is provided to the user.

CONCLUSION

This disclosure describes techniques of route-planning that optimize safety and overall convenience for alternate transport modalities such as bicycle, open-top vehicles, non-motorized vehicles, etc. and for pedestrians. The techniques leverage location data, traffic data, street-level imagery, aerial imagery, etc., and assign a score to a travel route based on expected quality of travel experience. Implementation of the techniques in a digital map or navigation application can offer a superior navigation experience to a thus-far under-served cyclist, pedestrian, and non-motorized vehicle user base.

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